COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

W. Tayloe Murphy, Jr.
Secretary of Natural Resources

PIEDMONT REGIONAL OFFICE
4949-A Cox Road
Glen Allen, Virginia 23060
(804) 527-5020
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Robert G. Burnley
Director

Gerard Seeley, Jr.
Piedmont Regional Director

November 21, 2003

King William County
McCauley Park
Pump Station
(King William WWTP)

Todd Rodgers
McCauley Park,, LLC
7240 Lee Davis Road
Mechanicsville, Virginia 23111

Dear Mr. Rodgers,

This Office, as prepared by, Balzer and Associates, Inc., has received plans and specifications for the referenced facility. The plans entitled "McCauley Park, Pump Station, Plans and Specifications" include 12 sheets and are dated April 2,2003 with revisions dated November 5, 2003. The specifications entitled "generator specs, electrical specs, and lift station control panel" are undated.

The project consists of the construction of a duplex, submersible pump station and 7000 linear feet of 6-inch force main. The station will be equipped with pumps rated at 250 gallons per minute at 150 feet TDH. The facility will be owned by the County of King William .

The facility has been designated Reliability Class II. The facility meets the requirements of this class by the use of a standby generator.

The evaluation of these plans and specifications has been confined to technical requirements and design criteria, as stipulated in the Commonwealth of Virginia *Sewage Collection and Treatment Regulations.*

In accordance with Virginia Water Control Law, *Code of Virginia*, 1950 as amended in Title 62.1, Section 62.1-44.19 and Title 32.1, Section 32.1-164, this letter report is to advise that the previously mentioned plans and specifications are technically adequate and are approved by this

Office with the condition that an Operations and Maintenance Manual is submitted for approval by the Department of Environmental Quality before issuance of a Certificate to Operate.

This letter is your Construction Permit.

Please be aware that other permit requirements may also apply to this project. If development of the site will disturb a total of one or more acres and will also result in a point source discharge of storm water, you will also be required to obtain coverage under the storm water general permit for construction activities prior to site development. Disturbance of streams and/or wetlands may also require permitting. If you believe that you will need additional permit coverage, please contact the Regional DEQ Office for the appropriate permit application forms.

One set of the previously described plans with Virginia Department of Environmental Quality approval stickers is enclosed.

For the Director, Department of Environmental Quality

Sincerely,

Raymond R. Barrows, Jr., P.E.
Area Engineer
Office of Wastewater Engineering

c: J. R. Bell, DEQ,PRO
Daniel J. Balzer, P.E., Balzer and Associates
Rueben Varghese, M.D., MPH, Director, Three Rivers District Health

BALZER AND ASSOCIATES, INC.
REFLECTING TOMORROW

LETTER OF TRANSMITTAL

DATE 7-23-03	JOB NO. H0200184
ATTENTION Reed Barrows	
RE McCauley Park Pump Station	

VIA
- ___ U.S. Mail
- ___ U.P.S.
- ___ Airborne Express
- ___ Fed. Express
- ___ Hand Delivered
- ___ Picked Up
- ___ Other _____

TO Division of Wastewater Engineering
1500 East Main St.
Richmond VA

WE ARE SENDING YOU ☐ Attached ☐ Under separate cover via _____ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

☐ Copy of letter ☐ Change order ☐ _____

COPIES	DATE	NO.	DESCRIPTION
2			Utility Plan

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submitted ☐ Resubmit _____ copies for approval

☐ For your use ☐ Approved as noted ☐ Submit _____ copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return _____ corrected prints

☒ For review and comment ☐ _____

REMARKS _____

COPY TO _____ SIGNED: Brandon Sovick

PLANNERS • ARCHITECTS • ENGINEERS • SURVEYORS
1208 Corporate Circle • Roanoke, Virginia 24018 • Phone (540) 772-9580 • Fax (540) 772-8050
501 Branchway Road • Richmond, Virginia 23236 • Phone (804) 794-0571 • Fax (804) 794-2635
880 Technology Park Drive • Suite 200 • Glen Allen, Virginia 23059 • Phone (804) 553-0132 • Fax (804) 553-0133
102 Hubbard Street • Blacksburg, Virginia 24060 • Phone (540) 961-0961 • Fax (540) 961-0962

Safeguard Business Systems LITHO USA FORM NO. 8113/L01CS001783 12/02 0V9-00

BALZER AND ASSOCIATES INC
REFLECTING TOMORROW

RECEIVED
NOV 10 2003
PRO

LETTER OF TRANSMITTAL

DATE	f11-05-03	JOB NO.	H0200184
ATTENTION	Reed Barrows		
RE	McCauley Park Pump Station		

VIA
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COPIES	DATE	NO.	DESCRIPTION
2			revised pump station plans for Resource submittal
2			soil study reports
2			generator specs
2			hammer analysis
2			electrical specs
2			lighting specs

THESE ARE TRANSMITTED as checked below:

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6/01

FORCE MAINS
REVIEW FORM

Page _____ OF _____
Date _____
Reviewed By: _____

Project: McCauley Park

DESIGN REQUIREMENT	REFERENCE	COMMENTS
Pipe diameter (inches): 6	C-1	
Length of pipe (feet): 6923	C-1	
Flow range through pipes (gpm): 248 gpm.	C-10	$\frac{248}{2.5 \times .36} = 3$
Discharge velocity(s) = 3 fps		
Are line sizes and velocities adequate? (Y)/N)		
Air relief valves: yes	SR C2-9	
Minimum Depth of cover: 3.5'	"	
Termination (point of hook-up) gravity drain	C1	
Pipe material(s): PVC.		AWWA, ANSI, etc. specs
Pipe specifications:		AWWA, ANSI, etc. specs
Joint specifications:		AWWA, ANSI, etc. specs Mechanical or push-on
Describe leakage testing (AWWA C-600): ✓		
Allowable leakage _____ gals/hr		
Bedding:	SR C1	Class A, B, or C, or equivalent
Bend restraints: mega-lug	SR C3	or restrainers
Provisions for water supply/line protection: future irrigation approaches.		per OWP regulations

10/01

PUMP STATION REVIEW FORM

Project: Mc Conley Park

Date 8/28/03

Reviewed By: RRB

REQUIREMENT		REFERENCE	COMMENTS
Location of Pump Station	vic Central Garage		
Buffer zone:	50± downhill	ok	100' recommended
Station Protected from 100-year flood:			
Fully operational during 25-year flood:		ok	
All-weather access road provided:	gravel	ok	

RECEIVING FACILITIES

Capacity of receiving sewer line _____ MGD _____ Adequate?

Capacity of receiving pump stations _____ MGD _____ Adequate?

Capacity of receiving STW = _____ MGD _____ Adequate?
_____ STP average flow (1 yr.) _____ MGD

accepted by Kim Williams County

PRETREATMENT

Discharge piping designed to prevent grit from settling in lines of pumps not in operation: (Y/N)

Briefly describe any pretreatment provided:
(restaurants must have a grease trap)

none

PUMPING UNITS

Type of Pumps Provided submersible

Number of pumping units provided: 2 minimum of 2

Pump No.	Friction Head (ft)	Static Head (ft)	Rated Capacity (gpm)	Rated TDH (ft)	Operating Capacity (gpm)	Computed TDH (ft)	Variable Constant Speed
1-2	34	118	248	151	248	152	C

STATIC HEAD: -

10/01

Project: McCawley Park

PUMP STATION REVIEW FORM

Page 2 OF 6
Date 8/28/05
Reviewed By: RRB

High point elev: 174
LWL elevation: 154
118

RESIDUAL HEAD: - 0

FRICTION HEAD; -

APPERTENANCE:

C = _____

EQ LENGTH OF PIPE, ft

Friction losses: 5280 x .034

FLOW (gpm)	RES + STATIC HD (ft)	FRICTION LOSSES (ft)	TDH (ft)	velocity (fps)	loss/100' (ft)
				$\frac{.248}{2.5 \times 6^{-2}}$ 2.81	

Plot FLOW against TDH on the next page (pump curve).

The pumps will operate at 248 gpm vs. 151 feet TDH,
to _____ gpm vs. _____ feet TDH.
powered by a 25 HP electric motor.

REQUIREMENT	REFERENCE	COMMENTS

Is capacity of pumping equipment adequate? (Y/N)

10/01

PUMP STATION REVIEW FORM

Date 8/28/03

Reviewed By: RBS

Project: McCawley Park

Can peak flow be pumped with largest unit out of service? (Y/N)

Alternating control: _____	sh 11 note 4	
Type of control mechanism: float switch	_____	Adequate?
Controls adequately protected from the weather: (inside or NEMA rated: _____)	sh 11	
Individual suction and intake lines: _____	N/A	
Suction line size _____ inches	N/A	4-inch minimum
Velocity (range) in suction line _____ fps	N/A	2 to 6 fps
Discharge line size 4 inches	_____	
Velocity (range) in discharge line _____ fps	OK	2 to 8 fps $\frac{.248}{2.5 \times 4^2}$ 6
Are line sizes and velocities adequate? (Y/N)		
Is gate valve provided on each suction line? (Y/N)	N/A	
Gate valve and check valve on each discharge line? (Y/N)	sh 10	both on each line
Size of spheres that pass through pump 3 inches	sh 10	minimum 3" diameter Can pass 2" if a ≤ 2" bar screen is provided
If less than 3 inches, explain: _____		

SUBMERSIBLE PUMP STATIONS

Provisions for pump quick disconnect & reconnect: Meyers Assembly	sh 10	for small stations
Hoist and accessories: _____	hoist	
Shut-off & check valves located in a separate vault? (Y/N)	sh 10	

SUCTION LIFT STATIONS

Net positive suction head requirements met? (Y/N)		
Gate valve provided on suction line? (Y/N)	_____	
Air relief piping on pump discharge line? (Y/N)	_____	min. 1.25" diameter
Pumps, shutoff, & check valves located outside wet well?	_____	
Separate access to wet well provided? (Y/N)	_____	

REQUIREMENT	REFERENCE	COMMENTS
WET WELL		
Is there mechanical equipment/screens which requires personnel to enter the wet well? (Y/N)	_____	If yes, there must be mechanical

PUMP STATION REVIEW FORM

Project: Mc Coubrey Park

Date 8/28/03

Reviewed By: R.P.T.

If "No", is a 4-inch downward-facing, screened vent provided? (Y/N) _____ ventilation

Volume from LWL to rim = _____ cu. ft. (next page) _____

Ventilation fan capacity _____ cfm _____

Air changes per hour _____
(30 air changes/hr minimum for intermittent operation)
(12 air changes/hr minimum for continuous operation)

air changes/hr = $\frac{\text{fan capacity} \times 60}{\text{volume}}$ = $\frac{(\quad \text{cfm}) \times 60}{(\quad \text{cu. ft.})}$ = air changes/hr

Is ventilation adequate? (Y/N)

Fan of non-sparking variety? (Y/N) _____

Adequate access provided? (Y/N) _____ to pull equipment

Adequate lighting provided? (Y/N) _____ to work at night

Wet well fillets provided? (Y/N) Slope _____ _____ minimum of 1:1

Wet well divided? (Y/N) _____
If "yes", properly interconnected? (Y/N)

Volume between LWL and pump 1 on = _____ gallons

Is design adequate to prevent both pump from overheating due to excessive starts and septic conditions due to excessive detention time? (Y/N)

DRY WELL

Adequate access provided? (Y/N) _____

Provisions for removing equipment? (Y/N) _____
Describe _____

Sump pump provided? (Y/N) _____ Back to wet well and down towards the water level
Discharge point _____

Volume of dry well = _____ cu. ft. _____

Ventilation fan capacity _____ cfm _____

Air changes per hour _____
(30 air changes/hr minimum for intermittent operation)
(12 air changes/hr minimum for continuous operation)

air changes/hr = $\frac{\text{fan capacity} \times 60}{\text{volume}}$ = $\frac{(\quad \text{cfm}) \times 60}{(\quad \text{cu. ft.})}$ = air changes/hr

Is ventilation adequate? (Y/N)

Wetwell:

PUMP STATION REVIEW FORM

Project: McCauley Park

Date 8/28/03

Reviewed By: RRD

VOLUME:

--Ground = 82

-- Inlet = 63

--Alarm = 62.5

--Pump #2 On = 61.75

--Pump #1 On = 59.28

-- Off = 56.5

-- Intake = 56.25

-- Floor = 56

B. OPERATING VOLUME:

$2 \times \pi \times 3.5^2 \times 7.48 = 575$

C. ABOVE ALARM VOLUME:

$(82 - 62.5) \times 3.5 \times \pi \times 7.48$

$\frac{20}{2} \times 575 = 5750$

23 min

CYCLE TIME

1. PUMP TIME = $\frac{\text{OPERATING VOLUME}}{\text{PUMP RATE - MIN. INFLOW}}$

$\frac{575}{248 - (.4 \times 100)} = 2.9$ min

2. FILL TIME = $\frac{\text{OPERATING VOLUME}}{\text{MINIMUM INFLOW}}$

$\frac{575}{100} = 5.8$ min

3. CYCLE TIME = 8.7

4. OVERFLOW TIME = $\frac{\text{ABOVE ALARM VOLUME}}{\text{PEAK FLOW IN}}$

NET POSITITVE SUCTION HEAD:

Atmospheric Head	(+)	33.9
Vapor Head	(-)	-1.0
Friction Head	(-)	
Suction or Head (+) Lift	(-)	
NPSH Available		
NPSH Required		

($NPSH_A$ must be > $NPSH_R$)

SUBMERGENCE:

Elevations

WETWELL

--Top =

A. TOTAL

Project: McCauley Park

PUMP STATION REVIEW FORM

Date 8/28/03
Reviewed By: RRB

REQUIREMENT	REFERENCE	COMMENTS
FLOW MEASUREMENT (IF PROVIDED)		
Type of measuring device RTI	OK	
Capacity _____ MGD Properly Sized? (Y/N)		
CROSS-CONNECTION CONTROL		
RPZ device on potable water line to pump station?	N/A	
If "No", explain		
Seal water system provided? (Y/N) Adequately protected? (Y/N)		
RELIABILITY		
Reliability Class II		
Provision for continuous operability provided?		
Describe provision standby generator Adequate? (Y/N)		
Is adequate power distribution provided? (Y/N)		capable of running the specified pumps
Breaker settings or fuse ratings adequate? (Y/N)		
Electrical control center locations adequate? (Y/N)		inside and be able to see the pump station
Are 3-phase motors adequately protected from short circuits and overloads? (Y/N)		check the phase that is available to the station
Low voltage protection for motors? (Y/N)		all pump motors
Emergency power equipment adequately located? (Y/N)		
Adequate emergency power generator starting system?	OK	battery with a trickle charge or can start three consecutive times
Alarm system provided? (Y/N)		
Describe _____		
Is the alarm system adequate for the designated reliability class? (Y/N)		

(Class I must monitor main power supply, auxiliary power supply, failure of each pump to discharge, and high liquid level in wet/dry wells; and be equipped with a test function and a back-up power supply. On-site audio-visual alarm required with telemetry to site manned 24 hours per day.)

(Class II/III must monitor high liquid level in wet well with on-site audio/visual alarm.)

LIFT STATION CONTROL PANEL

General:
Provide a pump control panel to sequence the pumps automatically in response to changing wetwell levels. The panel shall be a complete automatic control package consisting of variable frequency drives, pump sequencing logic, and discreet operator controls. The system shall operate completely unattended, and shall provide local and remote indication of abnormal conditions. The entire assembly shall be completely prewired and tested at the factory. The control panel shall be as manufactured by Metropolitan Equipment Company (Division of Metropolitan Industries, Inc. Romeoville, Il.).

Referenced Standards:
National Electrical Manufacturers Association (NEMA)
NEMA 250-1991, Enclosures for Electrical Equipment (1000 Volts Maximum)
Underwriters Laboratory
UL 508, Industrial Control Equipment

Operation:
The pump control panel shall be equipped with a microprocessor based, electronic level management system. The level management system shall be the LMS400 as manufactured by Metropolitan Equipment Company (Division of Metropolitan Industries, Inc. Romeoville, IL). The LMS shall receive an analog signal proportional to the level in the wetwell and sequence the pump(s) as required to maintain the desired set point. A "LEVEL IN FEET" bar graph shall display the actual wetwell level. The level management system shall provide totally automated sequencing of one, two, three or four pump(s). The LMS shall be easily configured for pump up and pump down applications.

An analog input shall be provided for wetwell level reference. The input signal shall be 0-5 vdc scalable or 4-20 ma. The LMS shall include an onboard ±15 vdc, 30 ma reference loop power supply. LMS input power shall be 120 vac or 24 vac. The LMS shall also be capable of operating on 12 vdc battery power for alarm system integration. The operating temperature range of the LMS shall be 0° to 40° C.

The level management system shall be capable of controlling up to four pumps and two alarms. High intensity light emitting diodes mounted on the face of the LMS shall display the level in 3 inch increments up to a total of 14 feet. Each pump and alarm set point shall also be displayed on the face of the LMS. The set point displays shall be the same high intensity LED vertical bar graph as the "LEVEL IN FEET" column. Pump on and pump off set points shall be independently adjustable providing true differential level control. All set points shall be adjusted by pushbuttons located on the face of the LMS. Controllers requiring the completion of live electrical circuits on the face, regardless of the voltage present, are not acceptable.

Trending LEDs shall be provided to indicate a rising or falling wetwell level. If the level is increasing at a rate of ¼ foot every five seconds or faster, the "INC" LED shall illuminate. If the level is dropping ¼ foot every five seconds or faster the "DEC" LED shall illuminate.

The LMS shall include a Hand/Off/Automatic mode selector with LED indication for each pump. In the "Hand" mode the pump(s) will turn on regardless of the level and continue to run until manually turned off. When "Off" the pump(s) will not run under any circumstances. In the "Auto" mode the LMS shall sequence the pump(s) automatically to maintain the wet well level. If a pump is required and run feedback is not sensed, the LMS shall lock that pump out and a illuminate a fault LED. A pump fault shall activate the common alarm circuit.

The level management system shall alternate the lead pump after each cycle. The LMS shall be capable of duplex, triplex, and quadraplex alternation. The LMS shall alternate each available pump, pumps that are faulted or out of service shall automatically be omitted from the alternation scheme. The operator shall also be

capable of manually selecting the lead pump.

The LMS shall include a level simulation circuit to allow the operator to test pump control and alarm functions. The simulation shall generate an artificial level signal independent of the actual wetwell level. The operator shall be able to simulate any desired level from zero through full scale. Control and alarm functions shall be operational when the LMS is in the simulation mode. The simulation circuit shall be designed such that the LMS cannot inadvertently be left in the simulation mode.

The level management system shall be equipped with two separate level alarm channels. Alarm circuits shall provide both local LED indication and output contacts for connection to remote alarm devices. Alarm on and alarm off set points shall be independently adjustable. Alarm set point displays shall be the same high intensity LED vertical bar graph as the "LEVEL IN FEET" column. The LMS shall provide individual pump fault indication and fault contacts. Level alarm and pump fault output contacts shall be rated 10 amps at 120 vac resistive / 10 amps at 30 vdc resistive.

A float switch back up circuit shall override the primary level control if the high level float is activated. The float back up circuit shall employ four level controls, pump off, start lead, start lag and high level. The lead pump shall be automatically sequenced on and off between the off float and the start lead float levels. Pumps shall be alternated on duty cycle. The controls shall sequence on the lag pump (and lead pump) should the wetwell level exceed the lag pump float switch level setting. The high level alarm float shall activate the specified alarm annunciation devices. If one pump should fail for any reason, the next available pump shall operate on the override control. Once activated, the control system shall remain in float back up mode until manually reset.

Construction:
The control panel and variable frequency drives shall be mounted in a free standing, traffic type main control enclosure. Enclosure shall be constructed of 12 gauge mild steel and finished with an industrial enamel. Provide double door construction with padlock hasp and staple. Double door enclosures shall be equipped with three point latch mechanisms. Enclosures shall include lifting eyes, ventilation louvers and painted steel subpanel. The main enclosure shall include a fan driven ventilation system and 1500 watt electric unit heater. Ventilation and heating shall be sized adequately to protect the equipment mounted within the main enclosure. The main control enclosure shall include an external alarm horn and alarm light.

Pump control components shall be housed in a separate NEMA type 1 enclosure mounted in the main control enclosure. Enclosure shall be constructed of 16 gauge galvanized steel and finished with ANSI 61 gray polyester powder coat inside and out. A lock hasp shall be provided on the outside door. Control components shall be mounted on a 12 gauge painted steel subpanel. Control panel shall be equipped with a door interlocked disconnect switch. Disconnect switch shall be a non-fusible, horsepower rated device with a through the door rotary operating mechanism. The disconnect shall be sized for the total connected load at the systems rated voltage. A service entrance rated utility disconnect and metering arrangement are to be supplied by the installing contractor.

The control panel shall be equipped with a secondary surge arrester. The surge arrester shall meet ANSI/IEEE Standard C62.11 for location Category C and the requirements of NEC Article 280.

The control panel shall include relays and wiring necessary to interface with monitoring equipment supplied by others. The following dry relay contacts shall be provided and wired to an interface terminal strip within the control enclosure:

- High water alarm
- Vepco power failure
- Pump 1 seal fail
- Pump 2 seal fail

Pump 1 motor thermal open
Pump 2 motor thermal open
Pump 1 run
Pump 2 run
Generator On/Off
Generator fault

Operator controls and indicators shall include:
Pump Hand/Off/Automatic selectors
Pump "Run" pilot lights
Elapsed time meters
Wetwell "High Level" pilot light
Alarm silence push-button
Float back up reset pushbutton
Outdoor Receptacle(2)

Selector switches and push-buttons shall be 22 mm, oiltight industrial type operator devices. Pilot lights shall be full voltage 22 mm, oiltight units.

Individual electrical components shall be mounted in accordance with the manufacturers recommendations. Wiring within the enclosure shall be run through plastic wiring duct or tied and bundled to prevent strain and abrasion. Control wiring shall be a minimum 18 AWG, type THHN or MTW. Power wiring shall be sized for the connected load but in no case less than 12 AWG, type THHN or MTW. All customer connections shall be wired to individually numbered terminals and wires shall be numbered at both ends for ease of trouble shooting.

The control panel manufacturer shall be listed with Underwriters Laboratories under UL508 (Type L) listing category for the manufacture of control equipment. The control panel shall contain UL listed components wherever practical. The entire control panel assembly shall be approved by UL and labeled to that effect.

Submersible Level Transducer:
Wetwell level shall be sensed with a submersible level transducer. The transducer housing shall be 316 stainless steel fitted with a SS cable support bracket. The transducer shall be designed for direct submergence in a tank or contractor furnished PVC stilling well. Liquid level shall be sensed by the deflection of a stainless steel diaphragm having a displacement of less than 5 cu.mm from 0 to full scale. The atmospheric pressure side of the diaphragm shall be bonded to a silicon strain sensor coupled to an integral bridge circuit. Atmospheric venting shall be through the signal cable, directly to atmosphere. Transmitters requiring separate, sealed, expansion breathing systems shall not be accepted. Electrical connection shall be 2 wire, 4-20 madc, and shall be reverse polarity and surge protected. Accuracy shall be 0.6 percent of full scale. Full scale range shall be 0 to 14 feet (or as shown on the plans). Temperature compensated range shall be -20 to 122 degrees f., maximum operating temperature shall be -40 to 176 degrees f.

Float Switch:
Float switch shall be steel tube mercury design sealed in a solid polypropylene float. Float shall be leak-proof and corrosion resistant. Power cord shall be 2 conductor #16 flexible cord type SJOW-A water and oil resistant, 300 volt. Switch rating shall be 2 amps at 115 or 230 volt ac. Float switch operating temperatures to 160°F. Provide support brackets as required or shown on the drawings. Float switch levels shall be adjustable from the surface.

VARIABLE FREQUENCY DRIVE

This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width

modulated (PWM) inverter. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years. The VFDs specified herein shall function as phase converters allowing operation of the specified three phase motors on the available single phase source. The motors shall be run at a constant preset speed to automatically maintain wetwell level.

Referenced Standards:
Underwriters Laboratories
UL508C
National Electrical Manufacturer's Association (NEMA)
ICS 7.0, AC Variable Speed Drives
IEC 16800 Parts 1 and 2

Qualifications:
VFDs and options shall be UL listed as a complete assembly.

Variable Frequency Drives:
The variable frequency drives (VFDs) shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, mounted in the main control enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), Integral Line Reactor(s), Capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device. The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.

Specifications:
Input 230 VAC ± 10%, 1 phase, 48-63 Hz. Output 230 VAC ± 10%, 3 phase. Output frequency 0 to 250 Hz. Environmental operating conditions: 0 to 40°C, 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.

All VFDs shall have the following standard features:
All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus. The keypad shall be removable, capable of remote mounting, and shall have it's own non-volatile memory. The keypad shall allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

The keypad shall include Hand-Off-Auto membrane selections. When in "Hand" the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off", the VFD will be stopped. When in "Auto" the VFD will start via an external contact closure. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Auto" and "Hand" modes.

The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip, the number of restart attempts, trial time, and time between reset attempts shall be programmable.

The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).

The VFD shall be equipped with an automatic extended control power loss ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Removing power from the motor is not an acceptable method of increasing power

loss ride-through.

The drive shall employ current limit circuits to provide trip free operation. The Slow Current Regulation limit circuits shall be variable to 150% (minimum) of the VFD's normal duty current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load. The Current Switch-off limit shall be fixed at 350% (minimum, instantaneous) of the VFD's normal duty current rating. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute in every 10 minutes.

The VFD shall have an integral Line Reator(s) to reduce the harmonics to the power line and to increase the fundamental power factor.

Two independently adjustable accel and decel ramps. These ramp times shall be adjustable from 1 to 1800 seconds.

The following operating information displays shall be standard on the VFD digital display. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of two operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

Output Frequency
Motor Speed (RPM, %, or Engineering units)
Motor Current
Calculated Motor Torque
Calculated Motor Power (kW)
DC Bus Voltage
Output Voltage
Heatsink Temperature (°F)
Analog Input Values
Analog Output Value
Keypad Reference Values
Elapsed Time Meter (Resettable)
kWh Meter (resettable)
mWh meter
Digital input status
Digital output status

The VFD shall have the following protection circuits. In the case of a protective trip, the drive shall stop, and announce the fault condition in complete words (alphanumeric codes are not acceptable).

Overcurrent trip 350% instantaneous (170%RMS) of the VFD's variable torque current rating.
Overvoltage trip 130% of the VFD's rated voltage
Undervoltage trip 65% of the VFD's rated voltage
Overtemperature + 90°C
Ground Fault either running or at start
Adaptable Electronic Motor Overload (I^2t). The Electronic Motor Overload protection shall protect the motor based on speed, load curve, and external fan parameter. Circuits, which are not speed dependant, are unacceptable. The Electronic Motor Overload protection shall be UL listed for this function.